Epilepsy & Behavior 23 (2012) 152–158

Contents lists available at SciVerse ScienceDirect

Epilepsy & Behavior

journal homepage: www.elsevier.com/locate/yebeh

Emergence of complex partial epilepsy-like experiences following closed head injuries: Personality variables and neuropsychological profiles

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ARTICLE INFO

Article history:
Received 23 September 2011
Revised 28 October 2011
Accepted 3 November 2011
Available online 27 December 2011

Keywords:
Complex partial epilepsy-like experiences
Neuropsychological impairment
Closed head injury
Minnesota Multiphasic Personality Inventory
Cattell 16PF
Differentiating populations
Epileptic spectrum disorder

ABSTRACT

To pursue Richard Roberts' epileptic spectrum disorder (ESD) and the emergence of complex partial epilepsy-like experiences, items and total scores for the ESD Inventory were examined for 185 patients who had sustained mechanical impacts (and were diagnosed with or without neuropsychological impairment) and a reference group ($n = 68$) of university students. Results from neuropsychological, personality, neurological screening, and interview data supported the role of temporal lobe origins for these experiences. The incidences of these experiences were sufficient to adversely affect adaptation and to produce psychiatric profiles. Although only 70% of the patients who were impaired versus not impaired could be differentiated by items from the ESD Inventory, >95% of the patients with scores >100 on the ESD Inventory displayed abnormal scores on more than four Minnesota Multiphasic Personality Inventory scales. These results support Roberts' ESD concept and strongly suggest that persistent, subclinical occurrence of these experiences could be the cause or major correlate of neuropsychological impairment for these patients.

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1. Introduction

The relationship between penetrating cerebral injuries and the development of posttraumatic epilepsy is well known. Percentages of patients who develop epileptic seizures or convulsions following such injuries have ranged from 7 to 57% [1]. The development of electrical epileptic seizures subsequent to closed head injuries is more ambiguous, particularly when there has been no cessation of consciousness. However as psychometric tools have become more sensitive and the subjective experiences of complex partial epileptic (electrical) seizures without secondary generalization to convulsions have been examined more systematically [2–6], there has been emerging evidence that subclinical electrical seizures following closed head injuries may produce a variety of temporal lobe epilepsy-like experiences (and their correlates) that interfere with adaptation [7–11]. The incidences of these reported experiences are the subject of the present study.

The relationship between temporal lobe epilepsy and a variable collection of subjective experiences often attributed to "functional problems" has been considered by several clinical groups. For example, Harper and Roth [12] described marked similarities between symptoms reported by patients diagnosed with temporal lobe epilepsy and symptoms of those diagnosed as displaying the phobia–anxiety–depersonalization syndrome. Much of this research was related indirectly to consequences of the environment of combat. Following mechanical or pressure-wave impacts associated with explosions, some personnel developed a loose collection of disabling symptoms, the term for which has shifted over the decades from cowardice, to malingering, to shell shock, to posttraumatic stress disorder.

That discrete and powerful experiences can be elicited during partial cognitive seizures, originating either naturally or through direct electrical stimulation, is well known [13–16]. Mental phenomena [17] evoked by electrical stimulation of the hippocampal formation and the amygdala through their connections with the cortices of temporal lobes are very similar to those reported in a more protracted manner by individuals who have sustained closed head injuries. A continuum exists between the numbers of coherent neurons activated, as discerned by stereo-encephalography [18], and the intensity of the subjective experience even without overt convulsions. The difference between 7 and 14% of neuronal coherence is the transition between normal consciousness and altered intermittent consciousness. As aptly reiterated by Rasmussen [19], seizure discharges that remain localized to the hippocampal region rarely result in clinical seizures but can obviously affect the representation of experiences, that is, memory.

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doi:10.1016/j.yebeh.2011.11.010

In addition, as reported by Goldensohn [20], nonconvulsive seizures are associated with paroxysmal discharges within scattered epileptogenic columns in the cerebral cortices that may not attain the "critical mass" to be discerned by surface electroencephalography. These correlative epileptiform activities occur interictally and would, theoretically, be sufficient to maintain a variety of covert processes that would maintain certain types of subjective experiences. Bear and Fedio's [21] well-known description of the temporal lobe personality, an interictal manifestation of a history of protracted overt seizures and convulsions originating from within the temporal lobes, might be considered the more intense manifestation of this process.

On the basis of their experience with combat veterans and repeated interviews, Roberts and his colleagues [4] considered the possibility of an epileptic spectrum disorder (ESD). Patients who display ESD differ from patients who are diagnosed with classic complex partial seizures in at least four domains. Patients with ESD exhibit partial seizure-like symptoms that do not occur in stereotyped sequences or as classic motor automatisms such as lip smacking. Only a minority of patients with ESD show clear epileptiform patterns during standard clinical EEG examinations, but are more likely to seek treatment for mood disorders, concerns about "going crazy" because of transitory cognitive problems, or atypical headache. The patient with ESD also endorses more partial seizure-like phenomena than do patients who exhibit frank complex partial epileptic seizures.

The concept was similar to that developed by Persinger and Makarec, derived from an alterative methodology and set of assumptions [2,22]. Roberts et al. [23] devised an inventory that appears to capture the fundamental experiences of individuals who meet the criteria for ESD who were primarily veterans with protracted difficulties adapting to the postcombat home environment and who did not respond to conventional neuroleptic compounds. About half of the population did respond to antiepileptic medication [24]. A similar observation was reported by Persinger [25], who noted that individuals who sustained mechanical impacts to the skull (without loss of consciousness), who displayed difficulties with postinjury adaptation, and who did not respond to tricyclic or serotonin reuptake inhibitor-type antidepressants often responded to antiepileptic compounds such as gabapentin (Neurontin) and carbamazepine (Tegretol) and, more recently, to weekly treatments of weak, physiologically patterned transcerebral magnetic field stimulation across the temporal lobes [26].

To explore the quantitative aspects of the possible relationship between ESD and closed head injuries, we examined a population of individuals who had sustained this trauma and for whom a large database of norm-referenced measures and clinical observations had been collected. In the tradition of classic neuropsychology and neuropsychological assessment, we employed the Halstead–Reitan Impairment Index criterion of >0.4 as brain impairment (or damaged) and <0.5 as no impairment. For comparison, first-year university students were selected. The primary approach was to compare the scores for Roberts' [23] ESD Inventory of 36 items and scores on a normal and abnormal (psychiatric) personality inventory to discern how the students and those patients, who were either not impaired or impaired, were similar or different.

2. Procedure

2.1. Subjects

A total of 68 men and women (approximately equal numbers of men and women, average age 19 years) from two sequential university years served as the reference population as a component of their academic studies. In the clinical group there were approximately equal numbers of men and women ($n=185$) who had been assessed over a 10-year period after sustaining an impact of mechanical energy (90% from motor vehicle incidents) to the skull. Approximately three-quarters of this population had been referred to the second author's private practice by either insurance companies or legal advocates. The remaining patients were self-referred. About 44% reported cessation of consciousness with a median duration of "coma" of 2 days; the median posttraumatic amnesia interval was 1 week. Although 56% did not report suspension of consciousness most of them did report being "stunned."

For most of these patients the event had occurred between 1 and 3 years before the assessment. The means (SD) for standardized scores for basic measures were 90 (11) for the Wechsler Adult Intelligence Scale—Revised (WAIS-R) Verbal IQ, 94 (14) for the WAIS-R Performance IQ, 97 (16) for the Wechsler Memory Quotient, 98 (14) for the Wide Range Achievement Test (WRAT) for Reading, 92 (16) for WRAT Spelling, and 86 (14) for WRAT Arithmetic. According to the Halstead–Reitan Impairment Indices, 93 of these patients were not impaired and 92 were impaired.

2.2. Primary tool: Roberts' Epileptic Spectrum Disorder Inventory

This psychometric tool [23] comprises 36 items. Each item is followed by six options: never, <1/month, 1/month, 1/week, >1/week, 1/day, and >1/day coded with integers from 0 to 6, respectively. The items, the basic themes of which are summarized in the tables, include olfactory, gustatory, visual, haptic, and auditory illusions; sick headaches; confusion spells; déjà vu; jamais vu; memory gaps; speech problems; automatic behaviors; staring spells; mental decline; depressive spells; chronic dysphoria; suicidal ideation; anxiety; panics; and temper outbursts. The minimum possible score is 0 and the maximum is 216.

2.3. Neuropsychological assessments of patients

The following psychometric tests, described previously [27,28], were administered to all patients: WAIS-R; Wechsler Memory Scale (WMS); WRAT-2 (Spelling, Reading/Decoding, Arithmetic); finger tap (left and right hands); foot tap (left and right feet); Spontaneous Naming (object, animals, and color); Trails A, Trails B; Verbal Fluency (C and S words); Chicago Word Fluency; Design Fluency; Conditioned Spatial Association Test; Category Test; Spatial Span; Speech Sounds; Seashore Rhythm; Auditory Closure; Dichotic Word Listening Test; Tactual Performance Test (TPT); grip strength and pegboard (left and right hands); Hooper Visual Organization Test; Stroop Word–Color Test; Rey–Ostereith Test (drawing and recall after 30 minutes); Auditory Verbal Learning Test (5 trials of 15 words from list A, a single trial of 15 words from list B, and then reiteration of both), Recognition of words in List A within a list of semantically similar words; Minnesota Multiphasic Personality Inventory-168 (MMPI-168, the first 168 items prorated); Cattell's 16PF (personality factors); and the Institute for Personality and Ability Testing (IPAT) Anxiety scale.

2.4. Structured neuropsychological interview symptoms

The structured interview involved a series of approximately 50 items of experiences or events that occurred since the injury. They included alterations in sensory modalities; muscle weakness; cognitive changes; affective alterations, for example, sadness, irritability, disrupted sleep/dreaming; hormonal alterations; and social interaction changes. Information on the occurrence of a sensed presence since the injury, the duration of posttraumatic dysmnesia and loss of consciousness from the injury, substance consumption (e.g., ethanol, THC), and total number and subtypes of medications was recorded.

2.5. Neurological screening

On the basis of clinical experience with more than 2000 patients with histories of various etiologies, the ratings 0 (normal), 1

(questionable), 2 (moderate), and 3 (severe) were applied to the following responses: repeated left–right conjugate passive eye movement to an alternating, laterally moving stimulus, passive following upward eye movement, ocular convergence and accommodation, light reflex and consensual reflex, voluntary left–right eye movement, upward eye roll (the strongest component of the Hypnosis Induction Profile, an index of suggestibility), repeated, rapid lateral and protrusive movements of the tongue, serial thumb-to-finger movements three times (each hand), nose-to-finger (examiner's) movements with each hand with eyes opened and closed, olfactory identification and memory, rapid supination and pronation of hands, rapid alternation of lateral hand movements on knees (a dysdiadochokinesis check), imitation of a rhythmic sequence, time standing on each foot with eyes opened and closed, and presence of the Romberg sign. The summed score of these indicators is strongly to moderately correlated with the severity of the neuropsychological impairment [29].

2.6. Electroencephalographic screening

At the end of the first day of testing all patients sat in a comfortable arm chair that was housed in a large acoustic chamber with minimal light. The EEG unit was outside of the chamber; it was a three-channel Grass P79 that we have employed to screen for extreme qualitative indicators and as partial validity for subjective claims of the patients. In addition to heart rate (QRS/minute) and measures of aperiodicity, silver disk electrodes were arranged over the frontal (F7, F8), temporal (T3, T4), and occipital (O1, O2) regions.

Bipolar measurements were initially employed, and the times for alpha rhythm dropout and the emergence of stage 2 sleep spindles were recorded. The proportional durations of alpha rhythms or theta rhythms were later quantified by counting (visual inspection) these events per second on the strip charts for the first 10 minutes. After 20 to 30 minutes, shifts in voltages comparisons from the EEG were completed by externally (without disturbing the patient) switching the input to the EEG to measure the left and right hemispheres for frontal–temporal, occipital–temporal, and frontal–occipital comparisons. The presence of heart rate artifacts was noted as was the presence of electrical seizures or any anomalous pattern. We have screened about 1000 patients and 500 university students with this technique over a 20-year period.

2.7. Statistical analyses

The essential procedure was to compare the population of first-year university students and the clinical population as a function of their impairment scores, that is, <0.5 = not impaired, >0.4 = impaired according to traditional Halstead–Reitan criterion. One-way analyses of variance were completed between the three groups and each of the 36 items as well as for the MMPI (3 validity and 10 clinical scales) and 16PF (Personality Factors). The total score for the ESD Inventory was correlated separately for each of the three groups for each of the MMPI scales to discern the internal consistency of any effect.

To explore the potential capacity of the ESD Inventory to differentiate patients who were impaired and not impaired, discriminant analyses were completed for all of the psychometric, clinical examination, and subjective reports as a function of impairment. Finally only those patients with total ESD scores more than 1 SD below the mean ($n = 30$) and 1 SD above the mean (n = 31) were employed to discern if any additional information could be gleaned. All analyses, including those that arose from the initial hypotheses, involved SPSS PC 16. Because the total numbers of subjects did not change and P was set at <0.01, degrees of freedom and F values are not presented for every result. The $P<0.01$ level was also selected to minimize the potential alpha error. Instead, measures of explained variance, either η^2 or Ω^2, are supplied to appreciate the magnitude of group differences.

3. Results

3.1. Clinical and reference group comparisons

There was no statistically significant difference in the total ESD Inventory score between the sexes and no significant correlation ($r = 0.03$) between the score and age of the person. The means and SD for the reference group (university students) and two patient groups (nonimpaired vs impaired) for the items from the ESD Inventory that statistically significantly differed are listed in Table 1. Effect size is also provided. The grand mean and SD for the items that did not significantly differ between groups are listed in Table 2.

The four top items that explained most of the variance between the patient groups and the student group were the incidence of reported experiences of sudden confusion, trouble thinking, headache/nausea, and partial numbness. The items on which the neuropsychologically impaired patients differed from the nonimpaired patients *and* the students (who did not differ from each other) were the incidences of metallic tastes, partial numbness, ringing noises, expression of nonsense words, feelings of sudden weirdness, drifts of awareness, memory gaps, no memory of events, and blank looks as reported by others.

The MMPI profiles of the three groups are illustrated in Fig. 1. The standardized SD for each of these measures is 10; scores between 30 and 70 are considered to be within the normal range. The actual SDs for our samples were between 10 and 12. As indicated by the figure, only the patient groups displayed average scores that were abnormal. The groups that sustained cerebral impacts and exhibited no neuropsychological impairment displayed abnormal elevations for the scales of depression and mania. Those patients who sustained impacts and were diagnosed with brain impairment displayed abnormal elevations on scales for hypochondria, depression, hysteria, and psychasthenia. To ensure that the differences were not an artifact of age, only those 20 patients who were the same age as the students were compared with the remaining population of patients. All MMPI scaled scores were similar except for Hy (hysteria scale). The young (student age) patients were significantly ($F = 13.60$, $P<0.01$;

Table 1
Frequency of occurrence (range: 0–6) of items from Roberts' ESD Inventory that differed significantly between the university students ($n = 68$) and the clinical patients with indices <0.5 ($n = 93$) and >0.4 ($n = 92$) administered full neuropsychological assessments.[a]

	Students		Clinical patients				
			HRI ≤0.4		HRI >0.4		
Item No./indicator	*M*	SD	*M*	SD	*M*	SD	%Ω^2
1. Metallic tastes	1.3[b]	1.3	1.4[b]	1.8	2.1[c]	2.2	3
5. Bugs on skin	2.1[b]	1.5	1.3[c]	1.8	2.2[b]	2.2	5
6. Partial numbness	1.2[b]	1.2	1.7[b]	2.0	2.8[c]	2.2	12
7. Ringing noises	2.2[b]	1.6	2.1[b]	1.7	3.2[c]	2.1	7
8. Headache/nausea	0.7[b]	0.8	1.4[c]	1.7	2.4[d]	2.1	13
9. Pronunciation	1.8[b]	1.6	2.7[c]	2.1	3.1[d]	2.3	6
10. Trouble thinking	2.5[b]	1.5	3.6[c]	1.9	4.6[d]	1.6	19
11. Nonsense words	2.1[b]	1.4	2.5[b]	2.1	3.5[c]	2.2	7
12. Sudden confusion	1.4[b]	1.3	2.1[c]	1.9	3.7[d]	2.2	20
13. Sudden weirdness	1.7[b]	1.5	1.6[b]	1.7	2.5[c]	2.1	5
16. Memory gaps	1.7[b]	1.9	1.8[b]	2.0	3.0[c]	2.1	7
17. Awareness drift	1.2[b]	1.5	1.5[b]	1.7	2.5[c]	2.2	8
19. No memory events	1.7[b]	1.6	1.9[b]	1.8	3.0[c]	2.0	8
21. Blank look	2.0[b]	1.6	1.7[b]	1.8	2.6[c]	2.3	4
29. Memory worsening	3.3[b]	2.4	2.2[c]	2.2	3.0[b]	2.2	4
34. Urine urgency	1.4[b]	1.9	0.7[c]	1.2	1.5[b]	1.8	4

[a]See text. %Ω^2 refers to the estimated percentage of variance of the score explained by group affiliation.
[b–d]b versus c, $P<0.05$; c versus d, $P<0.05$.

Table 2
ESD Inventory items that did not statistically differ significantly between the clinical patients and university students (total $n = 253$).

Item No./descriptor	*M*	SD
2. Aversive smells from nowhere	1.2	1.6
3. Peripheral vision events	2.0	2.0
4. Movement in peripheral vision	2.4	1.8
14. Familiar places not familiar	1.5	1.6
15. Déjà vu	1.7	1.5
18. Driving without remembering	1.5	1.5
20. Spells/"hypnotized" by bright object	2.0	2.1
22. Sometimes black out	0.5	1.1
23. Irresistible urge to sleep in day	1.5	1.8
24. Angry face while sleeping	0.4	1.1
25. Abrupt depression no reason	2.4	2.2
26. Panic for "no reason"	2.0	2.2
27. Extremely angry for "no reason"	2.1	2.1
28. Extremely angry and no memory	1.0	1.7
30. So depressed think of suicide	0.6	1.2
31. See cockroaches then not see	0.7	1.4
32. Think telephone ringing but its not	0.7	1.2
33. Pain in head not a headache	2.3	2.3
35. Wake up sweating, bed soaked	1.3	1.7
36. Vivid nightmares and insomnia	1.5	1.7

eta^2 10% of the variance) lower ($M = 61$, SD = 14) on that scale compared with the older patients ($M = 73$, SD = 12).

To discern if the relationships between total ESD Inventory score and MMPI scaled scores were similar qualitatively and quantitatively, correlations were completed for each group. The results are summarized in Table 3. ESD Inventory scores for all three groups were significantly correlated with the scores for frequency (F), hypochondria (Hs), depression (D), psychasthenia (Py), schizoid/eccentric thinking (Sc), and hypomania (Ma). All three groups did not show significant correlations with lie (L) and MF scales. However according to *z*-transformed *r* comparisons, the relationship between ESD Inventory scales and paranoia and psychopathic deviancy scales were significantly stronger for the students and brain-impaired patients than for the nonimpaired patients. Interestingly, the only statistically significant correlations (Spearman ρ) between ESD Inventory scores and the durations of posttraumatic amnesia and coma were −0.30 and −0.35, respectively, but only for those patients who were impaired.

3.2. Complex partial epilepsy-like experiences and the neuropsychological structured interview

The only significant correlation between ESD Inventory scores and clinical rankings was 0.32 for dizziness during passive left–right eye movements. Responses to the structured interview revealed correlations ($0.20 < \rho < 0.32$) for increased ESD Inventory scores and reports of phosphenes since the injury within the upper left and right peripheral visual fields (but not the lower visual fields), sounds of human voices in both ears, and tinnitus in both ears. Subjectively greater impairments for memory (0.44) and distractibility (0.33) exhibited the strongest relationship. The ESD Inventory score was positively correlated with consumption of antidepressants (0.24), pain medications (0.33), and total medications (0.44), but with diminished libido (−0.21) and increased incidence of separation or divorce since the injury.

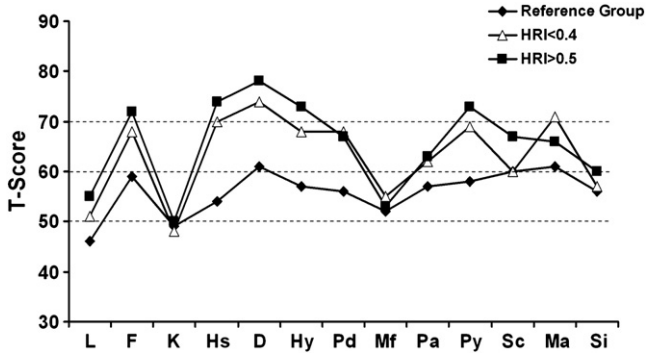

Fig. 1. *T* scores ($M = 50$, SD = 10) for the 3 validity and 10 clinical scales of the Minnesota Multiphasic Personality Inventory (MMPI) for the reference group (university students) and the patients who sustained a significant cerebral impact of mechanical energy and who were either not impaired (HRI < 0.5) or impaired (HRI > 0.4) according to traditional neuropsychological criteria.

Table 3
Correlations (Pearson's *r*) between the ESD Inventory total score and the MMPI scale scores for the three groups.[a]

		Clinical patients	
MMPI scale	Students	HRI < 0.5	HRI > 0.4
L	−0.14	−0.16	−0.33
F	0.63	0.60	0.67
K	−0.28	−0.26	−0.57
Hs	0.41	0.55	0.64
D	0.36	0.45	0.53
Hy	0.33	0.45	0.57
Pd	0.48	0.25	0.61
MF	0.14	0.10	0.09
Pa	0.54	0.26	0.49
Py	0.39	0.45	0.57
Sc	0.54	0.51	0.53
Ma	0.45	0.37	0.56
Si	0.12	0.17	0.31

[a] $r > 0.34$, $P < 0.01$.

The only correlation with any of the screening EEG measures was with duration of theta activity over the temporal lobes and that was negative (−0.21). This marginally significant negative relationship was evident for both the patients who were impaired (−0.24) and those who were not impaired (−0.28). However, the patients who were impaired demonstrated a significant correlation ($\rho = 0.36$) between the ESD score and the presence of heart rate artifacts (QRS) during the bipolar recording over the temporal lobes only.

3.3. Complex partial epileptic-like seizure experiences and formal neuropsychological test results

All of the correlations between ESD Inventory scores and those standardized cognitive and neuropsychological test scores for which there were significant values were between −0.18 and −0.30. These tests included: Verbal IQ, Performance IQ, Full Scale IQ, Rey–Ostereith (30-minute delayed) Memory, Immediate and Delayed Logical Memory from the WMS, Immediate and Delayed Figural Memory from the WMS, receptive vocabulary (Peabody), the second trial for the Auditory Verbal Learning Test (AVLT), accuracy in recognition of words that were in the list from the AVLT, sentence memory, speech sounds and Seashore Rhythm scores, and the fourth test of the Category Test.

3.4. Discriminant analyses of impaired versus nonimpaired patients by complex partial epilepsy-like experiences

Discriminant analysis for the optimal combination of the 36 items from the ESD Inventory to discern those with or without formal neuropsychological impairment selected only six items. The canonical correlation was 0.51 ($\chi^2 = 52.86$, $P < .001$) and correctly classified 70% of the cases. The items were (7) sudden ringing, buzzing, rushing, tapping sounds in ears; (8) headaches so severe as to cause nausea or vomiting; (12) sudden intense confusion; (15) experiencing something or having been in a place that you had not or were not; (16)

clear-cut gaps in memory; and (23) irresistible urge to sleep and no one can wake you.

3.5. Comparisons of lower and upper distributions of total scores for complex partial epileptic-like seizure experiences

To discern which tests, symptoms, and indicators significantly differed between the patients that had elevated ESD Inventory scores (>1 SD) and those that did not (<1 SD), these two groups ($n = 31$ and 30, respectively) were directly compared by one-way analyses of variance. The results in large part reiterated the previous measurements. The group with the highest scores made more errors (all F's with $P<0.01$) on the following tests: Design Fluency, the fourth block of the Category Test, the Wechsler Memory Quotient, the Recognition component of the AVLT, Sentence Memory, and Speech Sounds.

What was particularly revealing were the group differences for the symptoms. The percentages of the patients from the low- and high-score ESD groups, respectively, who reported various symptoms were: 4 and 34% for dizziness; 4 and 31% for hearing a voice that was not there in the right ear; 8 and 28% for phosphenes or flashing lights in the upper left visual field (compared with 7 to 8% for both groups for both left and right lower peripheral visual fields); 12 and 60% for tinnitus in the left ear; and 0 and 24% for tingling of the left leg. All other subjective experiences from the interview were not statistically significant.

For the qualitative EEG measures, which explained about 10% of the variance between the two groups for each variable, those with the highest ESD scores displayed the lowest proportion of theta activity over the frontal and temporal regions as well as the highest incidence of anomalous (i.e., not normal but would not meet the criteria of classic electrical seizures in either duration or form) activity between the frontal–temporal comparisons for the *right* hemisphere only.

3.6. Comparisons with the population of Roberts et al.

For an indirect comparison with the data of Roberts et al. [30] symptom incidence scores for less than 1 week were recoded as 0 and those for 1 week or more frequently were recoded as 1 for each of the ESD Inventory items. The percentages of endorsements for each of the 36 items for each group were then calculated. These are listed in Table 4. To discern the similarity between Roberts and colleagues' clinical populations, the 10 clinical MMPI scores were dichotomized such that any score ≥70 was set equal to 1 and any score <70 was set equal to 0. Only those patients with the lowest (less than 1 SD) or highest (total more than 1 SD score) were then compared.

Whereas 96% of the patients with the highest scores (total > 100) for complex partial epilepsy-like experiences as inferred by the ESD Inventory displayed scores >70 on at least four MMPI clinical scales, only 14% of those with the lowest scores displayed these elevations; that is, 86% displayed elevations on three or fewer MMPI scales. For comparison, the university students' scores were transformed similarly. Only ~9% of this population of 68 students (6 students) displayed scores >70 on four or more MMPI scales.

3.7. Intrinsic personality variables and complex partial epilepsy-like experiences

Although the concept of an "epileptic," that is, temporal lobe, personality [21] has been discussed in clinical populations as a qualitatively different manifestation compared with normal behaviors, there has been little examination of the relationship between classical personality variables and complex partial epilepsy-like experiences [31]. Spearman ρ correlations between the ordinal rankings (sten scores) for each of the 16 factors were completed for each of the three groups separately.

Table 4
Percentages of the populations from different groups that endorsed displaying these symptoms once or more times per week.

		Clinical patients	
	Reference	HRI<0.5	HRI>0.4
Symptom	($N=68$)	($N=93$)	($N=92$)
1. Metallic tastes	6	10	16
2. Aversive smells	9	17	36[a]
3. Peripheral vision events	25	25	39
4. Movement in peripheral	25	30	39
5. Bugs on skin	21	17	30
6. Partial numbness	7	20	40[a]
7. Ringing noises	22	23	55[a]
8. Headache/nausea	0	20	33[a]
9. Pronunciation	19	43	52[a]
10. Trouble thinking	24	58	80[a]
11. Nonsense words	15	41	59[a]
12. Sudden confusion	7	32	68[a]
13. Sudden weirdness	9	17	42[a]
14. Familiar places not	7	8	28[a]
15. Déjà vu	13	13	18
16. Memory gaps	9	25	49[a]
17. Awareness shift	4	15	43[a]
18. Driving without memory	10	17	21
19. No memory events	10	28	46[a]
20. Spells/hypnotized	15	27	35
21. Blank look	12	18	43[a]
22. Sometimes black out	0	3	3
23. Irresistable urge to sleep	12	28	16
24. Angry face while sleeping	3	9	6
25. Abrupt depression	18	28	39
26. Panic for no reason	15	20	30
27. Extreme anger no reason	4	28	36[a]
28. Extreme anger/no memory	0	8	14[a]
29. Memory worsening	6	28	44[a]
30. Depressed/suicide	1	2	10
31. See cockroaches/not see	3	8	10
32. Think hear telephone	1	3	4
33. Pain in head not headache	1	28	48[a]
34. Urine urgency	4	5	19
35. Wake up sweating	1	8	13
36. Vivid nightmares	1	15	25[a]

[a] $P<0.001$.

The only factor significantly correlated ($\rho = 0.34$) with the total ESD score for the student group was factor Q4 (tenseness). On the other hand, the patient population who had sustained an impact but were not neuropsychologically impaired displayed correlations with both factor C (emotional lability: –0.48) and factor Q4 (0.34). In other words, patients who reported more complex partial epilepsy-like experiences were more likely to become emotional when frustrated, evade responsibilities, and tend to give up.

The patient population who had sustained a mechanical impact and neuropsychological impairment displayed strong correlations between ESD score and factor C ($\rho = -0.64$), factor O (0.43), factor Q3 (−0.41), and factor Q4 (0.49). For these patients the increased incidence of complex partial epilepsy-like experiences was related to more emotional lability, greater apprehensiveness, a greater propensity to be careless of social rules, and more anxiety.

Finally, the means and SD for the sten scores (1–10) for the three groups are listed in Table 5. Although the means for all groups for all 16 factors were within the average range, unlike many of the MMPI scaled scores, there were still statistically significant ($P<0.01$) differences. With respect to intrinsic personality characteristics, the clinical groups were more emotionally labile, more concrete thinking, more moralistic, shrewder, and more tense than the student group. Stated alternatively, the students preferred more abstract concepts and were more expedient and relaxed than the patients.

Table 5
Sten scores for the 16 factors from the Cattell 16PF for the three populations.[a]

	Students		Clinical patients			
			HRI < 0.5		HRI > 0.4	
Factor	*M*	SD	*M*	SD	*M*	SD
A. Reserved–warm	5.2	1.8	5.0	1.9	5.0	2.0
B. Concrete–abstract	6.3[b]	2.2	5.1[c]	1.9	4.7[c]	1.5
C. Emotional–stable	5.7[b]	2.2	4.6[c]	2.0	4.7[c]	2.0
E. Submissive–dominant	6.2[ab]	1.6	5.9[b]	2.1	4.2[c]	2.2
F. Serious–impulsive	5.7[b]	2.3	5.6[b]	2.1	4.5[c]	2.4
G. Expedient–moralistic	4.5[b]	1.9	5.6[c]	1.9	5.9[c]	2.0
H. Shy–bold	5.8	2.1	5.2	2.0	4.9	2.2
I. Tough–emotional	5.9	2.4	5.9	1.9	6.3	1.7
L. Trusting–suspicious	5.8	2.0	6.6	2.0	6.3	2.0
M. Practical–imaginal	4.9	1.6	4.4	2.1	4.1	1.8
N. Forthright–shrewd	4.3[b]	2.2	5.7[c]	2.0	6.1[c]	2.1
O. Assured–apprehensive	5.6	2.1	6.2	2.1	6.6	2.2
Q1. Conservative–rebel	6.6	2.5	6.1	1.8	5.6	1.9
Q2. Group–self	6.6	1.8	6.6	2.2	6.2	2.2
Q3. Lax–will power	6.0	1.9	5.2	1.7	5.9	1.9
Q4. Relaxed–tense	6.0[b]	1.9	7.3[c]	1.8	6.7[c]	2.3

[a]Lower scores indicate behaviors more to the left, whereas higher scores indicate behaviors more to the right, of the dichotomous descriptor for each factor. (Sten scores from 4 through 6 are considered average range.)
[b,c]b versus c, $P < 0.05$.

The patients who were diagnosed as neuropsychologically impaired were more serious and submissive than either the patients who were not impaired or the students who did not differ significantly from each other.

4. Discussion

Experiences that are very similar to those reported by patients who display clinical epileptic seizures have been evoked by direct electrical stimulation of the deep structures and/or the primarily connected cortical regions of the temporal lobes. Emergence of interictal behaviors in clinical patients as well as the latency to overt forelimb clonus in rats rendered epileptic by either kindling or a single lithium/pilocarpine-induced seizure suggests that covert processes might continue long after the singular insult to the brain [32–35]. As shown by Babb et al. [18], a shift from only about 7% coherence to 14% coherence in neuronal firing within subcortical temporal regions, without obvious surface (electroencephalographic) manifestation, is associated with the transition from normal consciousness to interrupted consciousness.

Given the significant experimental research with rats that indicates inhibitory interneurons are particularly vulnerable to impacts of mechanical energy [36] as well as transient neurochemical perturbations leading to overt seizures, it would be expected that analogous conditions might exist within the human brain after comparable conditions. Maintained "dormancy" of inhibitory interneurons [37], which may occur for months to years even in rodents, would be expected to produce a more labile cerebral condition. Within the human cerebrum, intermittent disruptions in consciousness and its variants would be expected to be a primary correlate.

In the present study we found that the major items from the ESD Inventory that differentiated patients who were diagnosed as neuropsychologically impaired by formal testing from those who were not after an impact of mechanical energy to the skull reported more periods of sudden confusion, trouble thinking, headache/nausea, and partial numbness. The first two items would be consistent with the type of intermittent altered consciousness that might occur with phasic covert subcortical electrical seizures.

Secondary items, as defined by the lower strength of the amount of variance explained, were more frequent incidences of ringing noises, stating nonsense words, feeling of sudden weirdness, memory gaps, drifts in awareness, no memory of events, and episodes of "blank" looks. The most parsimonious interpretation of this cluster of symptoms would involve greater electrical lability within the temporal lobes. These experiences were more frequently reported for the patients who were neuropsychologically impaired than for those who were not or the students. Indirect verification of temporal lobe involvement was suggested by the correlations between ESD scores and the reports of phosphenes or other "light" flashes within the peripheral upper but not lower visual fields, as well as with the occurrence of tinnitus.

The weak but consistent diminishment of formal intelligence and memory scores for individuals with elevated complex partial epilepsy-like experiences could contribute to the reduced problem solving compared with the premorbid condition. As expected of all the neuropsychological tests employed, only those involved with memory and attention were most adversely affected. The magnitudes of the correlation coefficients indicate the behavioral manifestations would not be sufficient to be discerned easily within brief, qualitative interviews, per se, but would be sufficient to potentially affect the patient as he or she is exposed to the myriad stimuli during a standard working or living day.

There was some evidence of lateralization for those patients with the highest ESD Inventory scores (>100) compared with those with the lowest sores. The diminished accuracy for the former group involved Design Fluency, the fourth block of the Category Test, and the recognition component of the AVLT, all of which involve *right prefrontal* activity. It is interesting that the only EEG measure that was significantly correlated with such elevated ESD scores involved the numbers of anomalous events for the *right frontal–temporal* comparisons. Disruption of the right prefrontal regions, even intermittently, could diminish the accuracy of reconstruction of experiences, that is, memory, particularly autobiographical memories [38,39].

The patients who manifested neuropsychological impairment and elevated experiences similar to complex partial seizures as inferred from the ESD Inventory also had abnormally elevated scores on the MMPI for the Hypochondria, Depression, Hysteria, and Psychasthenia scales. If this group were a single patient, actuarial interpretation would be very clear. Patients with this profile focus on chronic symptoms which usually have their origin in the autonomic nervous system involving an actual organic pathology. These individuals are weak, moody, fearful, and inadequate and, during periods of regression, are unable to accommodate everyday stress and responsibilities. This "adaptation" may lead to chronic unemployment and many years of unproductive work [40].

On the other hand, those individuals who sustained a mechanical impact and were *not* impaired according to neuropsychological criteria, displayed a different profile with abnormal scores on the Depression and Hypomania scales. If this group were an individual, actuarial interpretations would reflect a person who either oscillates between periods of depression followed by impulsivity or who is engaged in a state of reflective rumination and self-absorption that is typical of the "identity" crisis of adolescence [40]. The question "Who am I?" and a feeling of a loss of the self or of being a different person than before the injury would be and actually is a common report by this population [9].

Discriminant analyses indicated that differentiating patients with formal neuropsychological impairments on the basis of an optimal combination of ESD Inventory items was only 70% accurate. Consequently the practical clinical value may be limited. Yet, individuals who had sustained mechanical impacts and who had ESD scores more than 1 SD above the mean could be identified in more then 90% of the cases based on elevations of four or more MMPI scales over 70. This combination of observations may suggest that not all elevations of ESD scores may be adversive and some sources of neuropsychological impairments may not involve substantial complex partial epilepsy-like experiences. However, for the subpopulation that does, a more precise intervention might be considered.

The profiles from the ESD Inventory are similar to that reported by Roberts et al. [23,30] for both their patients and their reference population. For the university students in our sample, about 10% displayed elevated ESD (>4) and MMPI scores that would be similar to those of patients who sustained a mechanical impact to the cerebrum and who were impaired. This proportion may appear excessive, but because of changes in recent admission criteria, it is not unusual for 1 of 20 to 25 students in first-year psychology classes to appear with notes from special needs offices because of a history of cerebral trauma.

We did not find the positive relationship between theta bursts and increased ESD scores reported by Varney et al. [7]. The reason for this is not clear and may reflect the different sources of our populations (in addition, the theta bursts were not that frequent, i.e., only about 10% of the patients displayed them). Our patients were referred primarily for neuropsychological assessments following motor vehicle incidents, whereas Varney and colleagues' group were military veterans. We think it is relevant that the presence of heart rate artifacts over the temporal lobes (but not the frontal or occipital regions) in our population was positively correlated with ESD scores. For bipolar recordings we have found these anomalies are often secondary to differential interhemispheric rates of blood flow. If this assumption is valid then differential rates of metabolism between the two temporal lobes could contribute to the experience of "complex partial epilepsy-like" experiences.

To our knowledge this is one of a few studies that have compared the putative premorbid personalities of patients who sustained a mechanical impact and are either impaired or not impaired. In many clinical practices, the 16PF is employed as an indicator of the person "before" the cerebral injury or the event. Obviously there is no definitive means to discern if the personality profile "determines" the occurrence of impairments, or if those with impairments who display this profile are more likely to be referred. The most obvious observation is that the mean scores, unlike the MMPI scales, were all within the average range. Clinical practice indicates that pre-injury personality strongly affects how the person adapts to the changes in experiences that occur following a cerebral trauma [41]. From this perspective the surprisingly strong correlations between epilepsy-like experiences and four different personality variables indicates that once a mechanical trauma occurs, similar processes or regions of the temporal lobe associated with the behavioral propensity may generate the labile electrically state associated with elevated complex partial epilepsy-like experiences.

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